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PRESBYTERIAN DAY SURGERY CENTER
ALBUQUERQUE, NEW MEXICO

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I. SUMMARY

On November 17, 1986, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate exposures to waste anesthetic gases and vapors in the operating rooms of the Presbyterian Day Surgery Unit, Albuquerque, New Mexico. The requesters were concerned with possible leakage from the anesthetic equipment used in the operating rooms at this facility.

In January 1987, NIOSH investigators conducted an environmental survey at the hospital. Personal and area air sampling and leak detection testing was conducted for nitrous oxide (N_2O) and halogenated anesthetic agents in the six operating rooms (OR's) where general anesthesia was being administered. In addition, measurements were taken to assess the adequacy of the general ventilation in the OR's.

Analysis of twenty-eight personal and general area air samples collected in the six OR's and recovery room revealed time-weighted average concentrations (TWA) of N_2O ranging from 0 parts per million (ppm) to 95 ppm, with a mean of 20 ppm. Five of these samples (18%) exceeded the NIOSH recommended exposure limit (REL) of 25 ppm for N_2O during the period of anesthetic administration.

TWA concentrations of ethrane in 14 personal and area air samples ranged from less than (<) the limit of detection (LOD) of 0.01 milligrams (mg) per sample to 3.63 ppm, with a mean of 0.31 ppm. Five of the samples (36%) exceeded the NIOSH REL of 0.5 ppm for halogenated anesthetics when used in combination with nitrous oxide. All of the six personal and area samples collected for isoflurane and halothane were below the limit of quantitation of 0.04 and 0.03 mg/sample, respectively.

Measurements of the general ventilation system revealed all six OR's to have in excess of twenty air changes per hour. During a portion of the survey, the general ventilation system for three of the OR's was inoperable. This would have likely resulted in higher than normal exposures in these OR's.

On the basis of the data obtained during this investigation, it was determined that a potential for overexposure to nitrous oxide and ethrane existed for employees working in the Presbyterian Day Surgery Center at the time of this survey. Recommendations are included in the full body of this report designed to reinforce the hospital's existing program for controlling employee exposures to waste anesthetic gases and vapors.

Key Words: SIC 8062 (General Medical & Surgical Hospitals) nitrous oxide, ethrane, halothane, isoflurane, halogenated anesthetics, scavenging

II. INTRODUCTION

On November 17, 1986, NIOSH received a request from employees at the Presbyterian Day Surgery Unit, Albuquerque, New Mexico, for a health hazard evaluation. The requesters were concerned with possible leaks in the anesthetic equipment used in the operating rooms at the facility.

On January 20, 21, and 22, NIOSH investigators conducted an initial/environmental survey at the hospital. During this survey, background information on the nature of the hospital operations was obtained, and personal and area air sampling was conducted for nitrous oxide (N_2O) and halogenated anesthetic agents. Leak detection for N_2O was also conducted in the OR's during surgical procedures. In addition, measurements were taken to assess the adequacy of the general ventilation system in the OR's.

III. BACKGROUND

The Presbyterian Day Surgery Unit, Albuquerque, New Mexico, provides outpatient surgery services for those individuals whose surgery does not require overnight stays. The Day Surgery Unit has six operating rooms OR's), with three rooms on either side of a central corridor. Each room contains an anesthetic cart equipped with a vacuum scavenging system. General ventilation to the OR's is supplied by two separate systems; one system which supplies air to OR No's 1, 2, and 3, and a second system which supplies air to OR No's 4, 5, and 6. In addition, down the hall from the OR's is a recovery room where patients are taken following surgery. Personnel involved in surgical procedures generally include as a minimum, the surgeon(s), an anesthesiologist, a scrub nurse, and a circulating nurse.

IV. MATERIALS AND METHODS

On January 20, 21 and 22, NIOSH investigators conducted an environmental survey at the Presbyterian Day Surgery Center. The survey was designed to assess employee exposures to N_2O and the halogenated anesthetic agents used during the course of the surgical procedures, as well as to identify potential sources of waste anesthetic gas exposure through leak detection using direct reading instrumentation.

Environmental samples collected for the assessment of employee exposures included both personal (collected in the vicinity of the employees breathing zone) and general area air samples (collected on the anesthetic cart near the breathing zone of the anesthesiologist). Samples for N_2O were obtained using battery-powered portable sampling pumps operating at approximately 200 cubic centimeters of air per minute (cc/m). The exhaust port of each pump was attached via Tygon tubing to an inert Tedlar bag. Samples were collected for the duration of the surgical procedure. Bags were immediately analyzed at a location outside of the operating room area using an infrared analyzer (Foxboro Miran 103 Specific Vapor Analyzer) in accordance with NIOSH analytical method 6600.[1] Samples were collected in each of the OR's in which the use of N_2O was anticipated. Additional information pertinent to sample collection is provided in Table 1.

In order to assess employee exposures to the halogenated anesthetics agents used during the surgical procedures, personal and area samples were collected at the locations previously described using battery-powered sampling

pumps operating at approximately 200 cubic centimeters of air per minute (cc/min). The pumps were connected via Tygon tubing to charcoal tube collection media. Samples were later analyzed in accordance with NIOSH analytical method l003, for ethrane, halothane, and isoflurane utilizing a gas chromatograph equipped with an flame ionization detector.[1] A listing of information pertinent to sample collection is provided in Table 2.

Leak detection for N_2O was conducted during the surgery procedures in the OR's. This included measurements taken directly at the anesthetic cart, scavenging system, and N_2O gas supply system. These measurements were made using a flexible sampling probe attached to the portable infrared analyzer.

In addition to the collection of environmental samples, ventilation measurements were made in each of the operating rooms using a Flow Hood (Shortridge Instruments). Calculations of the number of air changes per hour (ACH) were made in order to assess the adequacy of the general ventilation system in the OR's.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations [Recommended Exposure Limits or REL's], 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) [Threshold Limit Values or TLV's], and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) occupational health standards [Permissible Exposure Limits or PEL's]. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29 USC 65l, et seq.) to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Anesthetic Gases

Reports by Vaisman and Askrog and Harvald were among the first to identify an increased incidence of spontaneous abortion in women exposed to anesthetic gases and in wives of men exposed to anesthetic gases.[2,3] In 1974, the American Society of Anesthesiologists (ASA) published the results of a study indicating "that female members of the operating room-exposed group were subject to increased risks of spontaneous abortion, congenital abnormalities in their children, cancer, and hepatic and renal disease." This report also showed an increased risk of congenital abnormalities in offspring of male operating room personnel. No increase in cancer was found among the exposed males, but an increased incidence of hepatic disease similar to that in the female was found.[4]

In a study published by NIOSH in 1976, "N_2O and halothane in respective concentrations as low as 50 parts per million (ppm) and 1.0 ppm caused measurable decrements in performance on psychological tests taken by healthy male graduate students.[5] Nitrous oxide alone caused similar effects. The functions apparently most sensitive to these low concentrations of anesthetics were visual perception, immediate memory, and a combination of perception, cognition, and motor responses required in a task of divided attention to simultaneous visual and auditory stimuli." Headache, fatigue, irritability, and disturbance of sleep were also reported.[6,7]

Mortality and other epidemiologic studies have raised the question of possible carcinogenicity of anesthetic gases, but sufficient data are presently lacking to list N_2O or halothane as suspected carcinogens.

In a study of dentists, Cohen et al. compared exposed persons who used inhalation anesthetic more than 3 hours per week with a control group who used no inhalation anesthetic. The exposed group reported a rate of liver disease of 5.9 percent, in comparison with a rate of 2.3 percent in the control group. Spontaneous abortions were reported in 16 percent of pregnancies of the wives of exposed dentists, in comparison with 9 percent of the nonexposed. This difference was statistically significant; however, it should be noted that the rate of spontaneous abortions for all pregnancies ranges from 10 to 20 percent.[8] This study did not identify the specific anesthetic being used by the dentists surveyed, that is, whether they used N_20 alone or in combination with a halogenated agent.[9] However, in a review of that study, NIOSH concluded that "the halogenated anesthetics alone do not explain the positive findings of the survey and N_20 exposure must be a important contributing factor, if not the principal factor".[10] This conclusion is based on a calculation which assumed that as many as 1 in 10 of the dentists using an inhalation anesthetic employed a halogenated agent. If the actual fraction is less than 1 in 10, the conclusion has added strength.

In a document recommending a standard for occupational exposure to waste anesthetic gas, NIOSH recommended a maximum exposure of 50 ppm N_2O on a time-weighted average basis during the anesthetic administration in dental offices.[6] This recommendation is based primarily on available technology in reducing waste anesthetic gas levels in these environments.

When N_2O is used as the sole anesthetic agent in medical procedures, NIOSH recommends that occupational

exposure be controlled so that no worker is exposed at TWA concentrations greater than 25 ppm during the period of administration. NIOSH recommends that occupational exposure to halogenated anesthetic agents be controlled so that no worker is exposed at concentrations greater than 2 ppm of any halogenated anesthetic agent during the period of anesthetic administration. When used in combination with N_2O, halogenated anesthetic agents should be controlled to 0.5 ppm, which, generally, can be arrived at by controlling N_2O to a TWA concentration of 25 ppm during the period of anesthetic administration.[6] There is presently no OSHA standard for nitrous oxide or the halogenated anesthetic agents. However, in it's "Notice of Intended Changes" for 1986-87, ACGIH has proposed TLV's of 75 ppm for ethrane, and 50 ppm for halothane.[11]

VI. RESULTS

A. Nitrous Oxide

The results of the environmental samples collected for N_2O during the surgical procedures are presented in Table 1. As evidenced by these data, the TWA concentrations exceeded the NIOSH REL of 25 ppm N_2O in 5 (approximately 18%) of the 28 personal and area samples collected. TWA concentrations of N_2O ranged from 0 to 95 ppm, with a mean concentration of 20.3 ppm. The highest average concentrations of N_2O were found in the area samples collected on the anesthetic carts (27.7 ppm), followed by the personal samples collected on the scrub nurses (24.0 ppm), and the circulating nurses (17 ppm). Personal samples collected on the recovery room nurses had the lowest TWA concentrations of N_2O, with values ranging from 0 to 2 ppm. Personal and area samples which exceeded the NIOSH REL for N_2O were found in four of the nine surgical procedures monitored in three of the six operating rooms.

The results of the leak detection tests for N_2O conducted during surgical procedures revealed gas leakage from the spirometers on anesthetic carts to be a common problem. Concentrations of N_2O ranging from 250 to in excess of 1000 ppm were detected in the immediate vicinity of the spirometers on the anesthetic carts in OR No's. 1, 4, 5, and 6. Other sources of significant leakage included a hose connection in OR No. 6 at the point where it comes from the patient to the anesthetic cart which measured in excess of 1000 ppm. In addition, a concentration in excess of 1000 ppm was measured in the vicinity of a patients mouth during a procedure being conducted in OR No. 5. The endotrachial cuff was then adjusted by the anesthesiologist which resulted in an rapid decrease of the concentration to approximately 10 ppm.

B. Halogenated Anesthetic Agents

Table 2 shows the results of the environmental samples collected for halogenated anesthetics used during the surgical procedures. TWA concentrations of ethrane were found to range from below the limit of detection to 3.63 ppm. Five (approximately 36%) of the fourteen personal and area samples collected exceeded the NIOSH REL 0.5 ppm for halogenated anesthetic agents when used in combination with N_2O. Overexposures were noted in two of the five procedures in which ethrane was used, as well as in one personal sample collected in the recovery room. Concentrations of isoflurane and halothane were found to be below the limit of quantitation of 0.04 and 0.03 mg/sample, respectively, in all six samples collected for these substances.

C. General Ventilation

Calculations of the number of ACH based on ventilation measurements taken in the six OR's revealed the following: 21.8 ACH for OR No. 1, 22.6 ACH for OR No's 2 and 3, 24.7 ACH for OR No. 4, 24.0 ACH for OR No. 5, and 22.3 ACH for OR No. 6. While there are no NIOSH criteria for general ventilation, the Department of Health and Human Services "Guidelines for Construction and Equipment of Hospital and Medical Facilities" currently recommends a minimum of 20 total ACH for operating rooms[22] It should be noted that the above ventilation measurements were made on January 20, 1987. On January 22, it was noted that the general ventilation was not supplying air to the east side OR's (No's 4, 5, and 6). This was attributed to a device in the HVAC system which temporarily shut down the system to prevent damage from cold air being brought in from the outside during unusually low temperatures. It is not known for how long the system was inoperable.

VII. DISCUSSION AND CONCLUSIONS

As evidenced by the results of the environmental survey, both N_2O and ethrane were found to exceed the NIOSH recommended exposure limits during the period of the survey. Factors which may have contributed to these exposures included leakage from anesthetic cart components (i.e, spirometers), work practices (leakage from the face masks and endotrachial cuffs) and the inadvertent failure of a portion of the general ventilation system during the survey period. Since the exact magnitude which these and other factors may have influenced employee exposures can not be determined, it is necessary that all areas of exposure control be regularly examined to identify where improvements can be made. A brief discussion of some of the key areas necessary for controlling employee exposures is presented below.

Equipment Maintenance

Of primary importance in maintaining waste anesthetic concentrations within acceptable levels is the regular maintenance of anesthetic equipment in order to prevent leakage. Recent data indicates that leaks from the high and low pressure anesthetic delivery system resulting from poor maintenance of the anesthetic unit is a primary source of employee exposures in the OR.[13] Background N_2O levels of 5 ppm and greater generally have been associated with leaks in the high pressure gas delivery system, which includes the N_2O supply lines, the connections at and between the ceiling and anesthesia machine, and the connector-control valve from the flowmeter.[13] During anesthetic administration, low pressure leaks occurring between the flowmeters and breathing hoses (including the flowmeter, vaporizer, reservoir bag, popoff valve, endotracheal tube, automatic ventilator, and CO_2 absorber) can be a significant source of exposure. During the survey, leak testing of the anesthetic carts revealed leakage from the spirometer to be a consistent problem in the OR's.

Scavenging

Scavenging systems consist of a collecting device, means of disposal, and pressure balancing device if necessary. Depending on the particular type of anesthetic equipment in use, scavenging adapters should be located at the popoff valve for the circle absorber, nonbreathing valve, T-tube, and ventilator. In addition, scavenging may be necessary at locations such as the spirometer in the event that maintenance can not remedy

the present leakage. As with all scavenging systems, it is important to ensure proper pressure balancing so that the gas system does not interfere with the proper operation of the anesthetic delivery system.

General Ventilation

While local exhaust ventilation (such as scavenging) is the preferred means of eliminating waste gasses at their point of generation, general room ventilation also plays an important role in maintaining acceptable waste gas levels in the OR. Reasons for maintaining good general ventilation exchange rates include the rapid removal of waste gasses generated as a result of anesthesia induction, poorly fitting face masks, improperly inflated endotracheal tubes, or low or high pressure leaks which may occasionally develop in the system. As evidenced by the level of ethrane in the personal sample on the recovery room nurse, this is also an area in which maintaining good general ventilation is important. Since scavenging systems are not present in these areas, general ventilation is relied on to remove the waste gases expired by the patient. As a minimum, OR's should be supplied with at least 20 total air changes per hour, and recovery rooms with at least 6 air changes per hour.[12]

The inadvertent shutdown of the general ventilation system for three of the OR's which occurred during the survey may have resulted in some of the exposures reflecting higher than normal concentrations. While the temporary shutdown of this system may not have been preventable, provisions should be made to allow for rapid identification and correction to prevent such instances from occurring in the future.

Work Practices

Proper work practices are also a key element in controlling waste anesthetic gas exposures. One study estimated that 94 to 99 percent of all waste gas exposure in OR's equipped with properly designed scavenging components may be the result of poor work practices of the anesthetist.[14] Improper work practices include the use of poorly fitting face masks, insufficient inflation of endotracheal tubes, and spillage of volatile anesthetic agents while filling vaporizers. Despite constant attention to good anesthetic techniques, it is not always possible for the anesthesiologist to be aware of possible leakage from these sources. Therefore, it is important that the general ventilation be adequate to remove any waste anesthetics that might result from this source.

Exposure Monitoring

The Day Surgery Center periodically monitors employees working in the operating room area for nitrous oxide. In conjunction with periodic monitoring, ongoing leak detection is also a valuable method of assessing the effectiveness of exposure control mechanisms in the OR's.

VIII. RECOMMENDATIONS

While the Day Surgery Unit had in place engineering controls and implemented work practices which were generally effective in controlling exposures, two additional areas where further attention was needed were identified during this survey. These included:

(1) Correction of the leakage from the spirometers on the anesthetic carts;

(2) Examination of the general ventilation system and modification to prevent future shutdowns such as that encountered during the survey.

In addition, ongoing efforts are necessary to ensure that safe exposure levels are maintained in the future. Detailed recommendations regarding specific control procedures, work practices, and monitoring procedures are included in the NIOSH criteria for a recommended standard....occupational exposure to waste anesthetic gases and vapors.[8] In order to effectively control employee exposures in the operating room, a comprehensive program which addresses all of these areas is necessary. Due to the length of these recommendations they are not repeated in this section. In lieu of this, copies of this document have been provided separately to the Presbyterian Day Surgery Center. Adherence to the recommendations specified in this document should help to maintain exposures within acceptable levels and protect the health of the employees in this area.

IX. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods, Third Ed., Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984. (DHHS publication no. (NIOSH) 84-100).

2. Vaisman AI. Working conditions in surgery and their effect on the health of anesthesiologists. Eksp Khir Anesteziol 1967;3:44-9.

3. Askrog V, Harvald B. Teratogen effeckt of inhalations-anestetika. Nord Med 1970:83:498-504.

4. Cohen EN, Brown BW, Bruce DL, Cascorbi HF, Corbett TH, Jones TW, Whitcher C. Occupational disease among operating room personnel: a national study. Anesthesiology 1974:41:321-40.

5. National Institute for Occupational Safety and Health. Effects of trace concentrations of anesthetic gases on behavioral performance of operating room personnel. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-179).

6. National Institute for Occupational Safety and Health. Criteria for a recommended standard–occupational exposure to waste anesthetic gases and vapors. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-140).

7. Uhlirova A, Pokorny J. Results of questionnaire survey of health damage to anesthesiologists. Rozhl Chir 1976:53:761-70 (Cze).

8. Bond M. Statement of the american college of obstetricians and gynecologists on video display terminals and reproductive health to the house subcommittee on health and safety, committee on education and labor. Washington, DC, May 8, 1984.

9. Cohen EN, Brown BW, Bruce DL, Cascorbi HF, Corbett TH, Jones TW, Whitcher C. A survey of anesthetic health hazards among dentists: report of an american society of anesthesiologists ad hoc committee on the effect of trace anesthetics on the health of operating room personnel. JADA 1975;90:1291.

10. National Institute for Occupational Safety and Health. Control of occupational exposure to N_2O in the dental operatory. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-171).

11. American Conference of Governmental Industrial Hygienists. Threshold limit values and biological exposure indices for 1986 - 1987. Cincinnati, Ohio, American Conference of Governmental Industrial Hygienists, 1986.

12. Health Resources and Services Administration. Guidelines for Construction and Equipment of Hospitals and Medical Facilities. Health Resources and Services Administration, U.S. Dept. of Health and Human Services, 1984. DHHS Publication No. (HRS-M-HF) 84-1.

13. Gendreua L, Roberge, B. Monitoring of nitrous oxide in operating rooms: Paper presented at the american industrial hygiene conference. Institute de recherche en sante et en secutite du travail du Quebec. May 1985.

14. National Institute for Occupational Safety and Health. Development and evaluation of methods for the elimination of waste anesthetic gases and vapors in hospitals Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984. (DHHS publication no. (NIOSH) 75-137).

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from the NIOSH publications office at the Cincinnati, address. Copies of this report have been sent to the following:

A. Presbyterian Day Surgery Center, Albuquerque, New Mexico
B. Requester
C. U. S. Department of Labor, OSHA - Region V
D. NIOSH Regional Offices/Divisions

Table 1

Breathing Zone and General Room Air Concentrations of Nitrous Oxide
Presbyterian Day Surgery Center, Albuquerque, New Mexico
January 21 & 22, 1987

SAMPLE TYPE	LOCATION (OR No.)	SAMPLE DESCRIPTION	SAMPLING PERIOD	TWA CONCENTRATION NITROUS OXIDE (PPM)
(Samples Collected January 21, 1987)				
Personal	6	Scrub Nurse	7:22a - 8:30a	75
Personal	2	Circ. Nurse	7:25a - 8:17a	10
Personal	2	Scrub Nurse	7:30a - 8:10a	75
Area	2	Anesthetic Cart	7:34a - 8:15a	75
Area	1	Anesthetic Cart	8:25a - 9:58a	10
Personal	1	Circ. Nurse	8:21a - 9:55a	5
Personal	1	Scrub Nurse	8:23a - 10:03a	10
Personal	6	Circ. Nurse	9:05a - 10:06a	20
Personal	6	Scrub Nurse	9:05a - 10:20a	20
Area	6	Anesthetic Cart	9:15a - 10:12a	20
Personal	3	Scrub Nurse	10:11a - 10:58a	5
Area	3	Anesthetic Cart	10:17a - 10:51a	5
Personal	3	Circ. Nurse	10:15a - 10:55a	5
Personal	Recovery	Nurse	10:32p - 11:45p	2
Personal	4	Circ. Nurse	11:18p - 11:57p	15
Personal	4	Circ. Nurse	11:19p - 11:45p	15
Area	4	Anesthetic Cart	11:20a - 11:50a	95
Personal	Recovery	Nurse	11:50a - 1:30p	< LOD
(Samples Collected January 22, 1987)				
Personal	4	Scrub Nurse	7:25a - 8:43a	5
Personal	4	Circ. Nurse	7:25a - 8:43a	83
Area	4	Anesthetic Cart	7:35a - 8:45a	15
Personal	5	Scrub Nurse	8:17a - 9:34a	2
Area	5	Anesthetic Cart	8:22a - 9:32a	2
Personal	5	Circ. Nurse	8:17a - 9:34a	< LOD
Personal	Recovery	Nurse	8:47p - 10:12p	< LOD
Personal	5	Scrub Nurse	10:40a - 11:57a	< LOD
Personal	5	Circ. Nurse	10:40a - 11:59a	< LOD
Area	5	Anesthetic Cart	10:41a - 11:57a	< LOD

Evaluation Criteria - NIOSH REL - 25 ppm during the period of administration.
< LOD - Less than the limit of detection estimated at 1 ppm.

Table 2

Breathing Zone and General Room Air Concentrations of Halogenated Anesthetic Agents

Presbyterian Day Surgery Center, Albuquerque, New Mexico

January 21, 1987

SAMPLE TYPE	LOCATION (OR No.)	SAMPLE DESCRIPTION	SAMPLING PERIOD	TWA CONCENTRATION ETHRANE (PPM)	TWA CONCENTRATION ISOFLURANE (PPM)	TWA CONCENTRATION HALOTHANE (PPM)
Personal	6	Scrub Nurse	7:22a - 8:30a	< LOD	(0.37)	(0.09)
Personal	2	Circ. Nurse	7:25a - 8:17a	< LOD	NA	NA
Area	2	Anesthesia Cart	7:34a - 8:15a	< LOD	NA	NA
Personal	2	Scrub Nurse	7:30a - 8:10a	< LOD	NA	NA
Personal	1	Scrub Nurse	8:23a - 10:03a	NA	(0.17)	(0.16)
Area 1	Anesthesia	Cart	8:25a - 9:58a	NA	(0.14)	(0.40)
Personal	1	Circ. Nurse	8:21a - 10:15a	NA	(0.10)	(0.14)
Personal	6	Scrub Nurse	9:05a - 10:20a	0.40	NA	NA
Personal	6	Circ. Nurse	9:05a - 10:06a	(0.29)	NA	NA
Area 6	Anesthesia	Cart	9:15a - 10:12a	0.45	NA	NA
Personal	3	Scrub Nurse	10:11a - 10:58a	(0.31)	NA	NA
Personal	3	Circ. Nurse	10:15a - 10:55a	1.15	NA	NA
Area 3	Anesthesia	Cart	10:17a - 10:51a	1.06	NA	NA
Personal	Recovery	Nurse	10:32a - 11:45	1.26	< LOD	< LOD
Personal	4	Circ. Nurse	11:18a - 11:57a	1.15	NA	NA
Area 4	Anesthesia	Cart	11:20a - 11:50a	3.63	NA	NA
Personal	Recovery	Nurse	11:50a - 1:30p	0.17	< LOD	< LOD

EVALUATION CRITERIA: NIOSH REL - Halogenated Anesthetics, 0.5 ppm (when used in conjunction with N_20).

< LOD - Less than the limit of detection of 0.02 mg/tube for ethrane, and 0.01 mg/tube for halothane and isoflurane.
The values shown in parenthesis are those which were found to be above the limit of detection, but less than the limit of quantification. Therefore, these values are only considered to be estimates of exposures.